THE EFFECT OF pH AND THE PRESENCE OF OTHER ELEMENTS IN SOLUTION ON THE ABSORPTION OF BORON*

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Kahlenberg[1] has reported that boric acid is absorbed through living human skin whereas salts of boric acid are not so absorbed. These conclusions were based on experiments in which the subjects soaked their feet in alcoholic or aqueous solutions of the respective compounds for periods of approximately two hours. Apparently, no account was taken of the possible variation in skin permeability due to variation in solvent and pH.

Mulinos[2] reported on a study of boric acid absorption in animals and drew the conclusion that boric acid is absorbed from borated talc in sufficient quantity to lead to toxicity. This was a qualitative study only.

The following is the report of an experimental study in rabbits of the effects of varying pH and the presence of other cations on the transcutaneous passage of boron.

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EXPERIMENTAL PROCEDURE

The media used were (1) saturated (5%) boric acid in water, (2) a slurry of saturated boric acid (5%) and talc, (3) 8% sodium borate solution, (4) saturated (5%) boric acid in human urine, (5) 5% calcium metaborate slurry, (6) 5% boric acid in an ammonia-ammonium carbonate buffer of pH 9.0. In these studies, each of the preparations indicated was applied on gauze pads to the clipped animal. The portion of the body covered was the entire area between the forelegs and hind legs of the rabbits. Before application, blood was drawn from the heart and urine was collected by catheter where possible. The saturated pads were then applied and these were covered with transparent plastic sleeves to prevent drying. The pads were allowed to remain on the animal for eight hours, after which additional blood and urine samples were collected as described above. The samples of blood and urine were analyzed for boron concentration. The results of analysis of the pre-appli-

TABLE 1

The Absorption of Boron from Different Media-Intact Rabbit Skin

	No. of Animals	Urine Boron*				Blood Boron*			
		Base		Post Application		Base		Post Application	
		Average	Range	Average	Range	Average	Range	Average	Range
Saturated 5% boric acid sol.	12	8.1	6.0–10.0	20.0	10.0–20.0+	0.2	0.0–0.5	8.7	0.3–19.0
Saturated 5% boric acid in talc	13	10.1	0.9–20.0	9.1	0.9–20.0	1.1	0.2–3.1	1.0	0.6–1.6
Sodium borate (Borax solution 8%)	12	13.3	0.9–20.0	20.0	9.3–20.0+	1.3	0.3–3.2	11.6	3.2–20.0
Saturated 5% boric acid in urine	6	12.2	10.0–15.0	20.0	20.0	0.8	0.4–1.2	13.9	10.6–18.0
5% calcium metaborate solution	6	14.8	8.3–23.0	17.4	9.8–20.0	1.0	0.0–2.1	1.7	0.6–2.8
Saturated 5% boric acid in NH_3—$(NH_4)_2CO_3$ carbonate buffer	6	11.7	8.4–15.0	20.0	20.0	0.6	0.3–1.0	4.5	0.7–7.6

* Expressed as micrograms of Boron per milliliter. To convert to mg. % as boric acid multiply by 0.57

cation samples are listed under "base" columns in the table.

RESULTS

The results are shown in Table 1. There is a variable, but at times, strikingly high concentration of boron in the blood and urine of normal rabbits. This is due to the fact that some of the hay and grains in rabbit food require boron as an essential growth element and farmers, therefore, frequently use fertilizer enriched with boron salts in promoting such crops. It may be seen that boric acid, in 5% solution, is readily absorbed through rabbit skin whereas boric acid in talc, as well as in the form of calcium metaborate (5% slurry in water) yields little of no absorption. This is to be expected in view of the low solubility of calcium metaborate which is also formed by reaction of boric acid and talc. Boric acid in urine is apparently absorbed to the same extent as boric acid in water. However, boric acid in an ammonia-ammonium carbonate buffer at pH 9.0 is absorbed to a lesser degree than free boric acid but more than in the presence of talc. One surprising observation is the high absorption of borax. This is contrary to the conclusion of Kahlenberg[1] that salts of boric acid are unabsorbed while free boric acid is absorbed through intact skin. Their conclusions were based on studies on humans using alcoholic solutions of the respective chemicals. We believe that the permeability of the skin in their experiments may have been altered by the alcohol, thus giving rise to the disparate results.

SUMMARY

Experiments conducted on rabbits have shown:

(1) That free boric acid in aqueous solution or in solution in urine is readily absorbed through intact rabbit skin.

(2) That borax in aqueous solution is readily absorbed through intact rabbit skin.

(3) That calcium metaborate and boric acid in the presence of talc are very little absorbed through intact rabbit skin. This is undoubtedly due to the insolubility of calcium metaborate.

(4) That an increase in pH, established with NH_3—$(NH_4)_2CO_3$ buffer at pH 9.0 results in lesser absorption of boric acid from aqueous solution than is the case with boric acid in water alone. This is possibly due to a change in the permeability of the skin at this pH.

REFERENCES

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